



US010648570B2

(12) **United States Patent**
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(10) **Patent No.:** **US 10,648,570 B2**
(45) **Date of Patent:** **May 12, 2020**

(54) **GAS SEAL**

(56) **References Cited**

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U.S. PATENT DOCUMENTS

4,586,719 A 5/1986 Marsi et al.
5,014,871 A 5/1991 Mutter
(Continued)

FOREIGN PATENT DOCUMENTS

CA 1245685 A 11/1988
DE 3925403 A1 1/1991
(Continued)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/330,867**

OTHER PUBLICATIONS

(22) PCT Filed: **Aug. 22, 2017**

International search report and written opinion dated Nov. 14, 2017, for corresponding PCT/EP2017/071109.

(86) PCT No.: **PCT/EP2017/071109**

§ 371 (c)(1),

(2) Date: **Mar. 6, 2019**

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(87) PCT Pub. No.: **WO2018/050406**

PCT Pub. Date: **Mar. 22, 2018**

(57) **ABSTRACT**

(65) **Prior Publication Data**
US 2019/0219173 A1 Jul. 18, 2019

A gas seal which extends in a circumferential direction in an axis has a rotating slip ring and an axially movable stationary slip ring. A slip sleeve guides the stationary slip ring in the axial movement direction by a first sliding face on a second sliding face. The slip sleeve is fastened to a stator of the gas seal, wherein the slip sleeve has a first recess extending in the circumferential direction, and the stator has a second recess, opposite the first recess in the region of the fastening, extending in the circumferential direction, such that the first recess and the second recess define a common cavity extending in the circumferential direction. In the cavity there is an elongate fixing element which at least partially fills the first recess and the second recess such that an unlimited axial relative movement is only possible when the fixing element is radially deformed.

(30) **Foreign Application Priority Data**

Sep. 13, 2016 (EP) 16188480

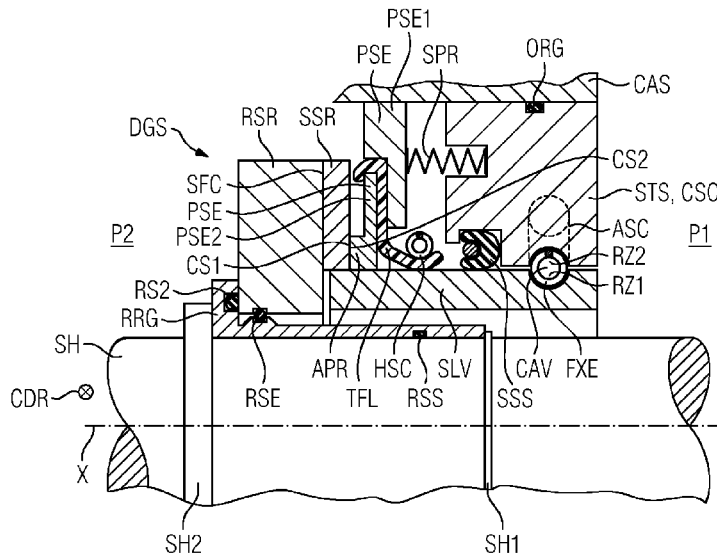
(51) **Int. Cl.**
F16J 15/34 (2006.01)
F16J 15/38 (2006.01)

(52) **U.S. Cl.**
CPC **F16J 15/342** (2013.01); **F16J 15/3464** (2013.01); **F16J 15/38** (2013.01)

(58) **Field of Classification Search**
CPC F16J 15/34; F16J 15/3436; F16J 15/3452; F16J 15/3464

See application file for complete search history.

13 Claims, 1 Drawing Sheet



(56)

References Cited

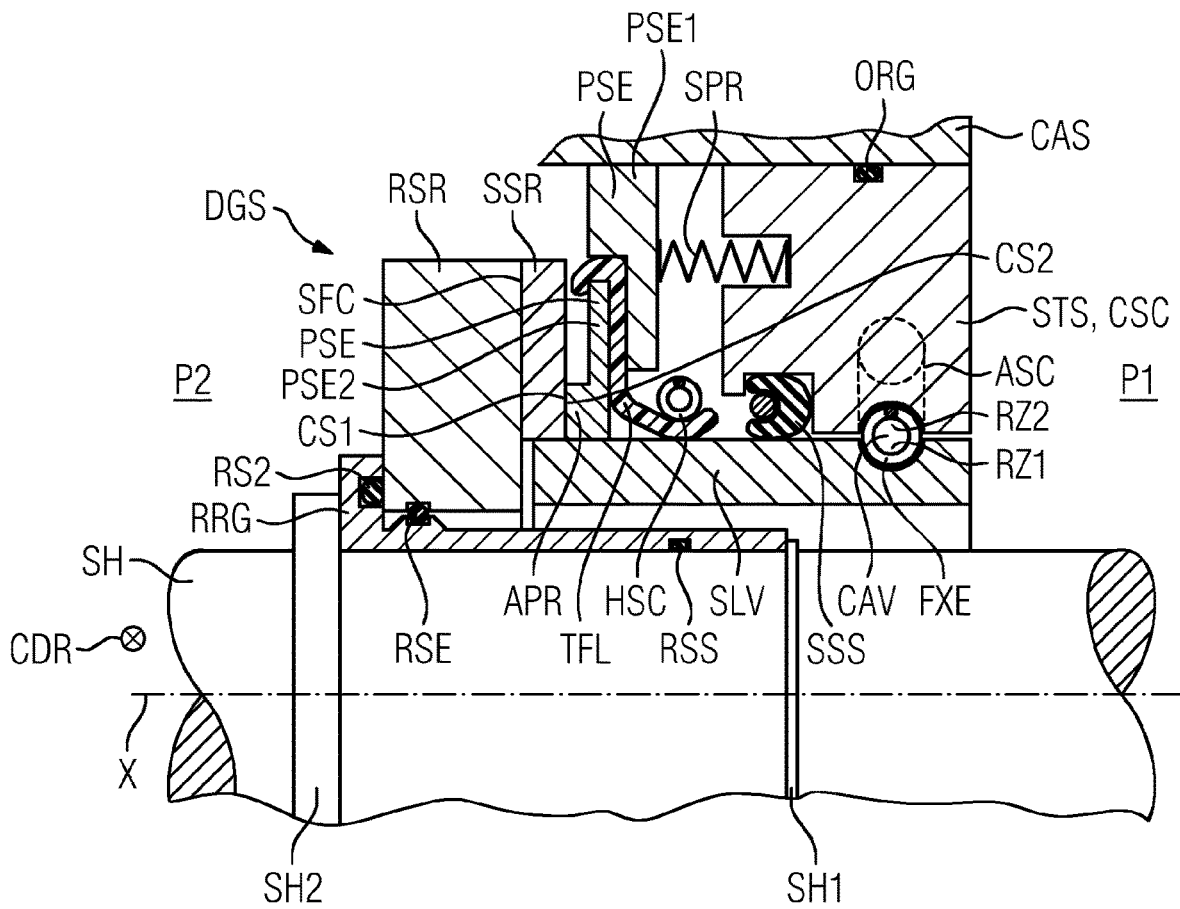
U.S. PATENT DOCUMENTS

5,370,403	A *	12/1994	Sedy	F16J 15/3452
				277/390
5,558,342	A *	9/1996	Sedy	F16J 15/3464
				277/390
9,518,473	B2	12/2016	Mateman	
2006/0103074	A1	5/2006	Droscher et al.	
2010/0283210	A1	11/2010	Kirchner et al.	
2015/0240951	A1	8/2015	Kirchner	

FOREIGN PATENT DOCUMENTS

DE	202007012050	U1	10/2007
DE	102011007071	A1	10/2012
EP	0134068	A1	3/1985
EP	0177161	A1	4/1986
EP	0315941	A2	5/1989
EP	0367721	A1	5/1990
JP	S6034576	A	2/1985
JP	2011509384	A	3/2011
RU	2622445	C2	6/2017
WO	2014023581	A1	2/2014
WO	2014037150	A1	3/2014

* cited by examiner



GAS SEAL

CROSS REFERENCE TO RELATED APPLICATIONS

This application is the US National Stage of International Application No. PCT/EP2017/071109 filed Aug. 22, 2017, and claims the benefit thereof. The International Application claims the benefit of European Application No. EP16188480 filed Sep. 13, 2016. All of the applications are incorporated by reference herein in their entirety.

FIELD OF INVENTION

The invention relates to a gas seal, in particular dry gas seal, which extends along a circumferential direction with respect to an axis, comprising a rotating slide ring and a stationary slide ring, wherein the stationary slide ring is axially movable, wherein the gas seal comprises a slide sleeve, wherein, by means of a first slide surface, the slide sleeve radially guides the stationary slide ring on a second slide surface along the axial direction of mobility.

BACKGROUND OF INVENTION

Gas seals or dry gas seals of the type defined in the introduction are already known from various publications. Examples of these are WO2014/037150 and WO2014/023581.

Dry gas seals of said type generally comprise components composed of ceramic, in particular manufactured from silicon carbide or tungsten carbide. The ceramic components are normally the stationary and/or rotating slide rings and, if appropriate, adjoining elements. A further example from the patent literature is given by DE 39 25 403 C2.

A gas seal of the type defined in the introduction is already known from EP 0 177 161 A1. EP 0 315 941 A2 presents the use of a spiral spring for the concentric connection of two components composed of different materials.

The thermal expansion of these ceramic materials amounts to approximately 3.5×10^{-6} m/K times meters. In comparison with this, the thermal expansion of steel, that material which is generally fitted adjacent to these ceramics of the seals, amounts to approximately 11×10^{-6} m/K times meters. The relative expansion between the ceramic components and the steel components resulting from this difference between the coefficients of thermal expansion has to be compensated accordingly, and so simple fastening of the ceramic shaft seal components to the steel components is not an option.

SUMMARY OF INVENTION

It is an object of the invention to provide a high-performance and simple technical solution for the fastening of the ceramic components to the steel components of a gas seal defined in the introduction.

To achieve the object according to the invention, a gas seal of the type defined in the introduction having the additional features of the claims is proposed. The dependent claims with respective back references encompass advantageous refinements of the invention.

Terms such as “axial”, “radial”, “tangential” or “circumferential direction”—if not specified otherwise—relate to the central axis in whose circumferential direction the gas seal according to the invention extends. Generally, said axis coincides with a shaft rotation axis, in relation to which the

gas seal forms a shaft seal in order to seal off a gap between a rotatable shaft or a rotor and a housing. It has been found that the fastening of a slide sleeve of a gas seal to a stator of the gas seal or to other housing components in the prior art constitutes a design which, for the most part, is highly cumbersome and takes up a large amount of space, in particular takes up a large amount of space in the radial direction.

Advantageously, the shaft seal or the gas seal according to the invention is designed in the form of an independently transportable insert (often also referred to as a cartridge), with the result that this modularity allows for example simple replacement of a defective gas seal with an intact gas seal. In principle, according to the invention, it is also possible for the stator to be a direct, if appropriate single-piece, component of the housing of the machine in which the gas seal is installed, for example a radial turbocompressor.

One advantageous refinement of the invention provides that the guide sleeve consists of ceramic, in particular of silicon carbide or tungsten carbide. The slide ring and the slide sleeve advantageously consist of said ceramics owing to their permanently high dimensional accuracy requirements.

In order that the fixing element is able to be fitted in an advantageously simple manner, according to an advantageous refinement, it is formed elastically such that a bending deformability is provided transversely with respect to the longitudinal direction of the fixing element. In this way, it is possible for the fixing element to be inserted, with corresponding bending, into the circumferentially extending curved cavity, advantageously tangentially. Particularly advantageously, for this purpose, either the stator or the slide sleeve itself has an insertion channel, opening out into the cavity, such that the fixing element is able to be introduced into the cavity through the insertion channel. The insertion channel expediently runs tangentially with respect to the cavity extending in the circumferential direction.

Another advantageous refinement provides that the fixing element is also designed in a manner deformable in the radial direction. For this purpose, the fixing element may be designed in particular in the form of a helical spring and particularly advantageously in the form of a tube spring or worm spring. In principle, it is possible here for the fixing element to consist of an elastic material or for example of a helically shaped steel profile which particularly advantageously has a flat profile. The helical spring or the fixing element can be introduced into the cavity in a manner substantially free of play or can be arranged in the cavity such that the slide sleeve is securely fastened to the stator. An elastic deformation of the fixing element gives rise to the additional advantage of an elasticity of the gas seal, in particular in the axial direction. Despite the axial flexibility, the fixing according to the invention of the slide sleeve is sufficient for establishing the required stability, in particular with respect to vibrations. Since the rotor also vibrates axially in the case of for example a turbomachine, the additional axial elasticity in the fastening of the slide sleeve is particularly advantageous for the seal.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is discussed in more detail below on the basis of an exemplary embodiment with reference to a drawing, in which:

FIG. 1 shows a schematic longitudinal section through a gas seal according to the invention.

DETAILED DESCRIPTION OF INVENTION

FIG. 1 shows a schematic longitudinal section through a gas seal according to the invention with an adjoining housing CAS and an adjoining shaft SH.

The gas seal DGS according to the invention is designed in the form of an insert which is able to be transported independently of the housing CAS and the shaft SH.

A rotor ring RRG is fastened radially and axially on the shaft SH by means of two shoulders SH1, SH2, wherein at least one, or the two shoulders SH1, SH2, is/are fastened in a detachable manner to the shaft SH in a way not illustrated in more detail. The rotor ring RRG has, toward the shaft SH, a rotating static seal RSS.

In the drawing, there is a machine inner pressure P2 on the left-hand side and a lower outer pressure P1 on the right-hand side.

A rotating slide ring RSR is fastened to the rotor ring RRG by means of a worm spring RSE, wherein the worm spring RSE allows an axial movement of the rotating slide ring RSR out of the target position only with radial deformation. The rotating slide ring RSR is sealed off with respect to the rotor ring RRG by way of a second rotating static seal RS2.

Axially opposite a sealing surface SFC of the rotating slide ring RSR is a stationary slide ring SSR with a corresponding sealing surface SFC, wherein, by means of a pressure element PSE, a spring SPR axially presses the stationary slide ring SSR by way of the sealing surface SFC of the latter against the rotating slide ring RSR.

The pressure element PSE is split axially into two portions which extend in a circumferential direction, a first portion PSE1 and a second portion PSE2, wherein, by means of the spring SPR, the two portions are pressed axially against one another and axially against the stationary slide ring SSR. The first portion PSE1 is of metallic design, and the second portion PSE2 is of ceramic design, advantageously being composed of the same ceramic as a slide sleeve SLV which extends in a circumferential direction and which serves as a guide for an axial movement of the pressure element PSE and the stationary slide ring SSR. The play between the slide sleeve SLV and the second portion PSE2 is formed to be small, with the result that the second portion, and thus the entire pressure element PSE, is guided in a manner radially mounted and axially displaceable. The illustration of the radial play of the slide sleeve SLV with respect to the elements slide ring SSR and pressure element PSE is not representative in the drawing, it also being possible at any rate for the play to be smaller, and also the ratio of the radial plays is not reproduced in a representative manner.

The second portion PSE2 bears with an axial projection APR, which has a first axial contact surface CS1, against a second contact surface CS2 of the stationary slide ring SSR. The two contact surfaces CS1, CS2 are formed in a manner lapped against one another, with the result that the almost play-free contact acts as a seal.

Between the two portions, a circumferentially extending Teflon seal TFL is arranged and held on the stationary slide ring SSR by means of the contact pressure of the pressure element PSE1 such that the two first portions PSE1, PSE2 bear sealingly against one another.

The stationary slide ring SSR is guided in a manner axially displaceable on the slide sleeve SLV with little radial play such that the mobility degree of freedom is limited to

the axial movement. Also, the second portion PSE2 of the pressure element PSE is likewise mounted. Both the stationary slide ring SSR and the slide sleeve SLV are manufactured from tungsten carbide or silicon carbide.

The Teflon seal TFL of the pressure element PSE extends radially inward beyond the contact surface between the two portions PSE1, PSE2 of the pressure element PSE. The Teflon seal TFL also extends axially beyond the transition point between the pressure element PSE and the slide sleeve SLV on the side with the higher pressure. Owing to the small radial play between the slide sleeve SLV and the second portion PSE2 of the pressure element PSE, the Teflon seal TFL is, under pressure, extruded only slightly into this radial gap such that a sealing action is ensured.

The stationary slide sleeve SLV is fastened to a stator STS by means of a fastening element FXE, wherein the stator STS is at the same time a housing CSC of the gas seal DGS.

A cavity CAV is defined by a first recess RZ1, extending in a circumferential direction CDR, of the slide sleeve SLV and by a second recess RZ2, extending in the circumferential direction CDR and situated opposite in the region of the fastening, of the stator STS.

The housing CSC of the gas seal DGS is sealed off with respect to the housing CAS of the turbomachine by means of an O-ring seal ORG. In principle, it is also conceivable for the housing of the turbomachine and the housing CSC of the gas seal DGS to be a single component. The fixing element FXE is able to be introduced tangentially into the cavity CAV through a substantially tangential insertion channel ASC.

The fixing element FXE is designed in the form of a worm spring and, accordingly, it is basically a helical spring, advantageously composed of a metallic material. For the purpose of sealing, a stator seal SSS is also provided between the slide sleeve SLV and the stator STS to maintain the pressure difference between the outer pressure P1 and the inner pressure P2.

It is alternatively possible for the fixing element FXE to be designed in the form of a wire, in particular in the form of a solid wire, that is to say without planned cavities in the cross section. The design in the form of a wire is particularly cost-effective and matches well with the possibility of the fixing element FXE which is able to be introduced tangentially into the cavity CAV through a substantially tangential insertion channel ASC. In this case, the deformability of the wire is generally sufficient to compensate for the different coefficients of expansion.

For the purpose of being secured in the desired position, the Teflon seal TFL is, by means of a helical spring element HSC extending in the circumferential direction CDR, pressed radially with the radially inner, projecting end against the slide sleeve SLV such that any differential pressure, in particular in the region between the static slide ring SSR and the slide sleeve SLV, in this case between the pressure element PSE and the slide sleeve SLV, is sealed off by the Teflon seal TFL. In this case, the Teflon seal TFL is partially extruded into a gap between the slide sleeve SLV and the pressure element. The helical spring element HSC holds the Teflon seal TFL merely in the position suitable for this purpose.

The invention claimed is:

1. A gas seal which extends in a circumferential direction with respect to an axis, comprising:
 - a rotating slide ring and a stationary slide ring, wherein the stationary slide ring is axially movable,
 - wherein the gas seal comprises a slide sleeve,

5

wherein contact between an outer surface of the slide sleeve and an inner surface of the stationary slide ring radially restrains the stationary slide ring while permitting movement of the stationary slide ring along an axial direction of mobility,

wherein the slide sleeve is fastened to a stator of the gas seal,

wherein the slide sleeve comprises an annular-shaped first recess extending in the circumferential direction, and the stator comprises an annular-shaped second recess extending in the circumferential direction and situated opposite the first recess in a region of the fastening, such that the first recess and the second recess define a common cavity which extends in the circumferential direction in an annular manner,

wherein, in the cavity, there is arranged an elongate fixing element which at least partially fills the first recess and second recess such that an unlimited axial relative movement is possible only when the fixing element is radially deformed.

2. The gas seal as claimed in claim 1,

wherein the slide sleeve consists of ceramic and the stator consists of metal.

3. The gas seal as claimed in claim 2,

wherein the slide sleeve consists, at least in portions, of tungsten carbide or silicon carbide.

4. The gas seal as claimed in claim 1,

wherein the fixing element is formed elastically such that a bending deformability is provided transversely with respect to a longitudinal direction of the fixing element.

6

5. The gas seal as claimed in claim 4, wherein the stator or the slide sleeve comprises an insertion channel, opening out into the cavity, such that the fixing element is able to be introduced into the cavity through the insertion channel.

6. The gas seal as claimed in claim 5, wherein the insertion channel runs, at least in portions, substantially tangentially with respect to the cavity.

7. The gas seal as claimed in claim 1, wherein the fixing element is designed in the form of a helical spring.

8. The gas seal as claimed in claim 7, wherein the fixing element is designed in the form of a solid wire.

9. The gas seal as claimed in claim 1, wherein the fixing element is designed in the form of a wire.

10. The gas seal as claimed in claim 1, wherein the gas seal is a dry gas seal.

11. The gas seal as claimed in claim 1, wherein the fixing element is designed in the form of a tube spring or worm spring.

12. The gas seal as claimed in claim 1, wherein the fixing element holds the slide sleeve radially apart from the stator thereby forming a gap therebetween, and wherein radial movement that closes the gap compresses and elastically deforms the fixing element where the gap is closed.

13. The gas seal as claimed in claim 1, wherein the fixing element comprises an elongate spring that is elastically radially compressible relative to a longitudinal axis of the elongate spring, wherein relative movement between the slide sleeve and the stator requires radial elastic deformation of the fixing element.

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